INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:

Multi Particle Dark Matter: Dynamics and Phenomenological Implications

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Thesis Submitted to the Department/ Center : PHYSICS
Date of completion of Thesis Viva-Voce Exam : 28.01.2020
Key words for description of Thesis Work : **Multi Particle Dark Matter, Electroweak Vacuum Stability; Neutrino Physics**

SHORT ABSTRACT

Discovery of 'Higgs' boson at LHC in 2012 validates the Standard Model (SM) of par-ticle physics as fundamental governing theory of Strong, Weak and Electromagnetic interactions. However many unresolved issues persist. Existence of Dark Matter (DM) is one of them. In spite of many astrophysical hints for DM, we do not have much knowledge about it, barring from its electromagnetic charge neutrality, gravitational effect at large scale and stability. As a result, nature of DM, as a fundamental particle, whether scalar, fermion, vector boson (or with even more exotic spin) or admixture of them in multipartite form remain an open question. The only measured quantity related to DM is its relic density which can be achieved mainly via two mechanisms: (a) thermal freeze-out and (b) non-thermal freeze-in. Weakly interacting massive particles (WIMP) are most popular DM candidates due to their discovery potential at direct and collider searches. The main idea of the thesis is to explore multi-particle DM scenarios in WIMP paradigm with non-negligible DM-DM interaction and study effects in relic density, direct search and collider signal. Apart from DM, explaining correct neutrino mass within SM is a difficult task. We therefore also aim to connect multipartite dark sector to neutrinos and see its phenomenological interpretation. Amongst other constraints, Higgs vacuum stability is studied in elaboration. We choose the simplest single component WIMP like DM framework, a real scalar singlet as a base model. In the first work, we extend it by another scalar singlet to serve as second DM component stabilised by additional $Z_2 \times Z'_2$ symmetry, having Higgs portal interactions. We show DM-DM interactions help to achieve a larger allowed parameter space through relic density and direct search constraints. In the second work, a two component DM model is addressed where in addition to scalar singlet DM, a fermion DM is assumed which arises due to singlet-doublet admixture of additional vector like fermions. Presence of a mediator between the dark sectors opens up a large parameter space through DM-DM conversion. Hadronically quiet dilepton signature, arising from the fermion dark sector is aided at LHC by the presence of a lighter scalar DM component. In the last work, inert $SU(2)_L$ scalar doublet acts as the second DM component and aids vacuum stability. Neutrino mass generation is addressed by the presence of heavy right handed neutrinos, which destabilise the Higgs vacuum. While DM-DM interaction helps achieving a large allowed parameter space, high scale validity puts further constraints, for example, on the mass splitting between the charged and neutral component of inert doublet, which has important implication to its leptonic signature(s) at LHC.